Advances in Life Science and Technology
ISSN 2224-7181 (Paper) ISSN 2225-062X (Online)
Vol 31, 2015

www.iiste.org

Impact of the Use of MBL, Simulations and Graph Samples in Improving Ghanaian SHS Science Students' Understanding in Describing Kinematics Graphs

Victor Antwi
Department of Physics Education, University of Education, Winneba, Ghana
Email of author: vicantwi@yahoo.co.uk

Abstract

Ghanaian SHS science students have difficulty when it comes to describing the shapes of kinematics graphs, conversion of kinematics graphs, getting the meaning and calculating slopes (especially from curved graphs) and areas under kinematics graphs, as they are not used to practicing these approaches in the classrooms. They describe shapes of graphs as pictures and give interpretation without taking into cognizance of the type of graph being considered. In this paper, students from experimental group were introduced to the use of microcomputer based laboratory (MBL) tools, simulations and graph samples to practice and describe the shapes of kinematics graphs, convert one form of graph to the other, calculate and get the meaning of slopes and areas under kinematics graphs, whereas students from the control group were introduced to the same topics by the use of the traditional lecture approach, where the teacher only talks and students listen. Students in both the experimental group and the control group were made to answer "Test of Understanding Graphs in Kinematics (TUG-K) before and after the introduction of the two instructional formats as pre TUG-K and post TUG-K respectively. Their scores were compiled and converted to mean proportion scores and average normalized gain $\langle g \rangle$, and compared. The outcome of the results did indicate that students from the experimental group, who were introduced to the use of MBL, simulations and graph samples had better interactive teaching and learning, did better in describing the shapes of kinematics graphs, transforming kinematics graphs, calculating and getting the meaning of slopes and areas under kinematics graphs and as such have better conceptual understanding in kinematics graphs than the students from the control group who were introduced to the same concepts using the traditional lecture approach.

Keywords: Ghanaian science students, Kinematics graphs, MBL

1. Introduction

Most Ghanaian Senior High School (SHS) science students could easily plot graphs when they have the values to be used in plotting and also determine the gradients especially when they are straight line graphs. Perhaps, the reason might extend from the fact that they have been plotting graphs and deducing the values of the slopes from their experimental values especially during science practical periods. However, these teaching techniques of graphs have made it difficult for SHS science students when it comes to describing the shapes of kinematics graphs, conversion of kinematics graphs, getting the meaning and calculating slopes (especially from curved graphs) and areas under kinematics graphs, as they are not used to practicing these approaches in classrooms. They describe graphs without taking into cognizance whether it is a displacement(x), velocity (v) or acceleration (a) versus time (t) graphs (x, v, a-t graphs). Conversion of displacement-time graphs to velocity-time graphs or velocity-time graphs to acceleration-time graphs, calculating and giving meanings to slopes and areas under graphs by most of these students leave much to be desired. In this study, two SHS science schools of equal/similar strength will be grouped into experimental and control group. How the use of the MBL and simulations will help students describe and transform kinematics (x, v, a-t) graphs, and to use specific examples of kinematics graphs to get the meaning and calculate for slopes and areas under graphs to improve interactive engagement teaching and learning and enhance students' conceptual understanding of kinematics graphs of the experimental group will be considered. The impact of the use of traditional lecture method to teach these concepts on students from the control group will also be considered. Results of the pre TUG-K and post-TUG-K of the experimental group and the control group will be converted into mean proportion scores and average normalized gain $\langle g \rangle$ and compared to see the impact of the use of MBL, simulations and graph samples on improving SHS students' understanding in describing the shapes of kinematics graphs.

2. Review of related literature

2.1 Why do graphs matter anyway?

From the standpoint of many scholars, graphs are a part of science that are used everywhere. They are used in industry, business, weather stations and medical fields. Graphs show trends throughout history, political polling data or even engine readings on an automobile or airplane. Graphs are not just a part of science; they are an essential skill to master (Redding, 2014). Using visual representations such as graphs to present data surveys, or other evaluation activities makes them easier to understand (Minter & Michaud, 2003). Graphs are excellent way to illustrate results.

Notwithstanding the importance of these graphing activities, research has shown that students struggle with the construction, transformation and interpretation of graphs in a physics context (Beichner, 1994: McDermott, Rosenquist & van Zee, 1987; Creswell & Plano-Clark, 2007). In the last three decades research has begun to show us that there are considerably better methods of teaching all students to be science minded to some extent. Halloun and Hestenes (1985) published their research on introductory physics students at Arizona State University. Among their conclusions, they noticed that students have their own preconceived notions about motion and its causes. These preconceived notions have a profound effect on student's performance in class and traditional approach of teachings do little to correct these beliefs (Halloun & Hestenes, 1985). These same ideas of preconceived notions could be extended to the erroneous reasons students give to interpreting the concepts of graphs in physics.

One area of students' difficulty lies with understanding kinematic graphs. Kinematic graphs involve position, velocity or acceleration plotted as a function of time. Mokros and Tinker point out some of the common errors as:

- thinking the graph is a literal picture of the motion. Students tend to think if an object rolls down a bumpy road then the graph will look like a bumpy road
- confusing a large slope of the line with the height of a point on a line. The students believe the largest slope must involve the line with the highest value on the graph.

Traditional lecture method of teaching does not appear to be solving these problems (Sokoloff & Thornton, 1997). Tebaabal and Kahssay (2011) also made the point that graphing allows students to use fundamental principles in physics in a nonverbal way. Students taught by traditional lectures fail to learn these fundamental concepts.

Crouch and Mazur (2001), and Kulik and Kulik (1991) showed that increasing students' engagement through discussion, the use microcomputer based laboratory (MBL) tools or simulations is what helps to increase students' understanding. Students need to be engaged through discussion with peers. Instruction has to become more student centred, rather than lecture centered, to improve graphical skills, concepts in kinematics and removal of misconceptions in graphs (Ellis & Turner, 2002; McDermott, 1993). Other researchers have developed their own "interactive engagements" strategies to give students more hands-on involvement in the classroom. They all have the same goal in mind of engaging the students and increasing conceptual learning in physics (McDermott, 2001; Moll, 2002).

2.2 How do students see graphs?

Two of the most commonly cited papers on graphing in physics investigated students' difficulties when interpreting kinematics graphs. McDermott, Rosenquist, and van Zee (1987) investigated college and high school students' difficulties in graph interpretation and found that difficulties could be separated into two categories:

- difficulties connecting graphs to physical concepts and
- difficulties connecting graphs to real world phenomena.

Difficulties with connecting graphs to physics concepts included knowing whether to extract information from the slope or the height (known as slope/height confusion), relating graphs to each other, matching a narrative with a graph, and interpreting area under the curve. The challenges with connecting graphs to real world phenomena included difficulties in understanding graphical representations of continuous motion, constant acceleration, and negative velocity. Additionally, students struggled to separate the shape of the graph from the path of motion, an error commonly called the "graph-as-picture" error.

In a similar study, Beichner (1994) developed a multiple-choice assessment for high school and college physics students. Though students had already received instruction on graphing, the mean student score was a meagre 40%. Through analyzing student responses, Beichner identified six common errors in interpreting these kinematics graphs. Since students from Ghana are also like students elsewhere, in order to help them more fully to understand the important practice of graphing, instructors need to recognize these six common errors that Beichner identified and develop interventions to correct them:

- First, students interpreted the shape of the graph as the shape of the motion of the object (graph-as-picture error).
- Second, students used the height of the graph to respond to questions requesting the slope (slope/height confusion).
- Again students confused area, height, and slope.
- Additionally, students did not draw appropriate distinctions between variables such as velocity and

acceleration, neglecting changes that should occur in the graph when these variables are changed.

- Students also struggled to find the slope of lines that did not pass through the origin
- Lastly, students struggled to interpret the meaning of area under the graph.

3. Research question

Could MBL, simulations and graphs samples promote students interactive engagement teaching and learning, and enhance students' conceptual understanding of kinematics graphs?

4. What are the characteristics of an effective teaching approach in kinematics graphs?

After studying the literature the following sequence of activities were used in the teaching of kinematics graphs; *concept quiz, conceptual reasoning questions, interactive teaching, reflection, application and problem solving questions*. The purpose of using these activities has been summarized in Figure 1:

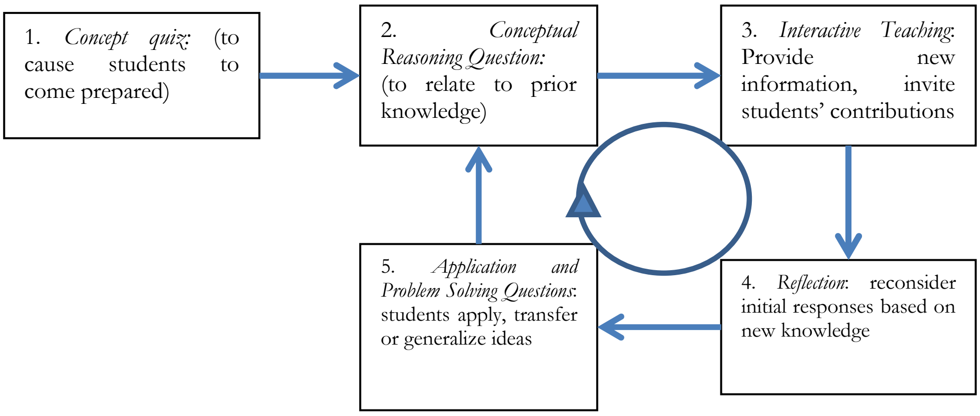


Figure 1: Learning activities and purpose

5. Research setting

Two science schools of equal qualities and strength were selected from the central region. Equal qualities in terms of numbers and passes in WAEC results and are also found in the capital cities of two municipalities. In order to conceal the identities of the two senior high schools, they are labelled as School A and School B. The class size of school A was 45 and that of school B was 43. School A was the experimental group and school B was the control group. Participants were form two (second year) science students. Form two students were chosen because they are not the final year class and as such the pressure of concentrating on possible examination questions will not allow them to fully pay attention or participate will not be on them. Also, in their second year they might have been taught with the use of computer or (Information and Communications Technology, ICT) tools during their first year in school, hence the possibility of having some knowledge in the use of ICT in learning. School B was about 40 km from school A. In all one week was used for the teaching of the kinematics graphs. Students from both schools were tutored for one-and-a-half hours after their normal class hours in the evenings. The experimental group (School A) was taught using microcomputer based laboratory (MBL) tools, simulations and graphs all in an interactive engagement manner to explain kinematics graphs while the traditional lecture method was used in teaching of the control group (School B). The researcher taught the experimental group (School A) and also supervised their pre- and post-tests, while in the control group (School B) they were taught and supervised by their Physics class teacher.

6. Method

6.1 TUG-K

TUG-K is a multiple-choice standardized test, which consists of 21 questions with students common misconceptions as distractors. It is designed to assess students' graphing abilities and their interpretation of kinematics graphs. The persistence of certain difficulties in concepts of graphs has been demonstrated by test of understanding graphs in kinematics (TUG-K), designed to assess students' conceptual understanding in graphs (Beichner, 1994). This instrument has been used to make physics teachers aware of the fact that many students have conceptual difficulties after teaching kinematics graphs.

6.2 Pre TUG-K

Students from school A and B were made to answer *(pre)* TUG-K questions in their various schools a day before the teaching on kinematics graphs. Their mean proportion pre- TUG-K scores were gathered (Beichner, 1994;

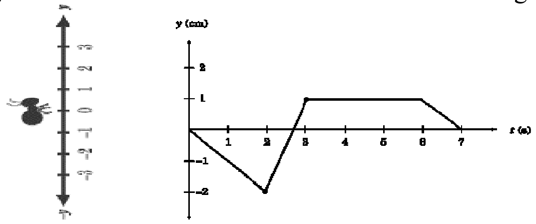
Dimitrov & Rumrill, 2003).

6.3 Experimental group

In the same day the experimental group was introduced into the use of the MBL tools. During the period of lesson students from the experimental and control groups were made to answer a concept quiz based on description of position-time graph, transformation of position-time graph to velocity-time graph and calculation of gradients.

6.4 Concept quiz question

In the graphs below, you will examine the movement of an ant running back and forth along a line.

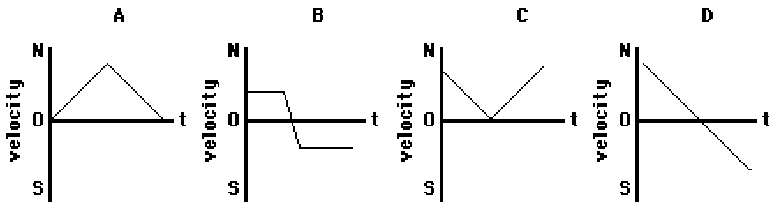


i. Give a brief Interpretation of the position-time graph using the movement of the ant.
ii. Transform the position-time graph of the ant into a velocity-time graph.
iii. Determine the gradients of the various movements of the ant; from t=0-2s, 2-3s, 3-6s and 6-7s.

After a short discussion of the questions, both groups of students were made to answer a question on a graph to activate their prior misconception on seeing a graph as picture (GAP). They were made to discuss in groups of four and choose the correct graph which best describes the question. This session was termed as the conceptual reasoning question.

6.5 Conceptual reasoning question

Little Johnny stands at the bottom of a small hill and kicks a ball. The ball rolls up the hill and then rolls back to Johnny. Which one of the following velocity-time graphs (A, B, C, or D) most accurately portrays the motion of the ball as it rolls up the hill and comes down?



The next activity was the interactive teaching, where students from the experimental group (School A) was made to form groups of four members and were made to predict and practice with the use of MBL and motion sensors to plot graphs of their own movements (straight line graphs). This is shown below:

6.6 Interactive teaching

By the use of motion sensors/detectors and coach students from the experimental group (School A) are to observe displacement-time graphs, velocity-time graphs and acceleration-time graphs of the motions below by their movement;

- standing still; students analyze and describe the displacement-time graphs, transform it to velocity-time graphs and acceleration-time graphs of the motion by comparing the shapes of graphs.
- moving at constant speed in a specific direction; students analyze and describe the displacement-time graphs, transform it to velocity-time graphs and acceleration-time graphs of the motion by comparing the shapes of graphs.
- moving away and coming back at constant speed; students analyze and explain the shapes of the displacement-time graphs, transform it to velocity-time graphs and acceleration-time graphs of the motion by comparing the shapes of graphs.
- moving away and coming back with different speed; students analyze and explain the displacement-time graphs, transform it to velocity-time graphs and acceleration-time graphs of the motion by comparing the shapes of graph.
- moving away, stopping and coming back; students analyze and explain the displacement-time graphs,

transform it to velocity-time graphs and acceleration-time graphs of the motion by comparing the shapes of graphs.

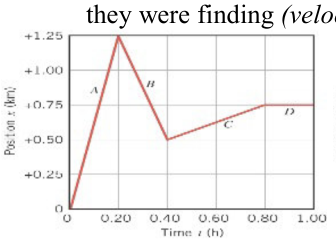
- students were made to walk some already plotted x-t and v-t graphs.

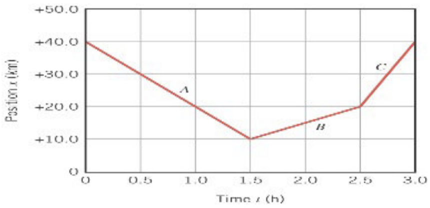
By the use of simulations, students from experimental group predicted and practiced curved x-t graphs and their transformations to v-t and a-t graphs. For example

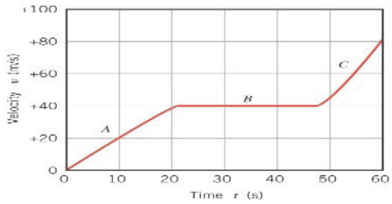
- students were made to study different dot diagrams of x-t motions with a changing velocity (curved graphs) and their transformations to v-t and a-t graphs. Thus positive and negative changing velocities (slow to fast and fast to slow) were considered.
- They were also made to enter different values for initial position (m), initial velocity (m/s), acceleration (m/s^2) and time (s). Students were made to study the shape of the position time graph and transform the shapes to v-t and a-t graphs.

Students (experimental group) were made to calculate for the slopes and areas of already plotted graphs. Thus

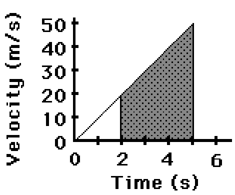
- students were made to practice and determine the value of slopes of a straight line graphs in x-t and v-t graphs (graphs starting from origin and graphs not starting from origin). They were to determine what they were finding *(velocity, acceleration)*.

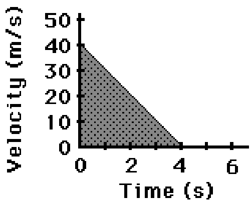






- students were made to practice and determine the areas under the straight line graphs of velocity-time graphs. They were to determine what they were finding *(total distance/displacement)*.





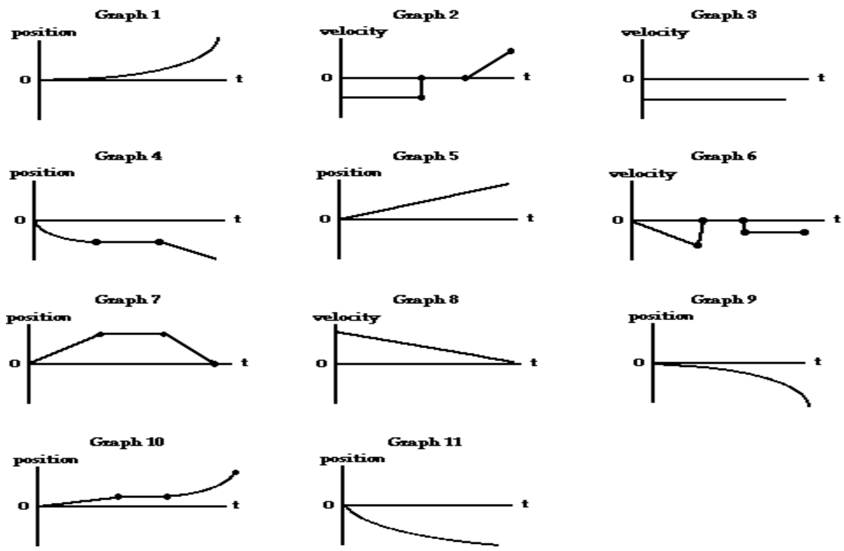
6.7 Reflection

After allowing the students from the experimental group to interact with MBL and simulations, they were made to reflect on their initial answers to the *conceptual reasoning question* to see if they could improve on their answers *(Reflection)*. Majority of the students opted for "D" as the graph that accurately portrays the motion of the ball as it rolls up the hill and comes down.

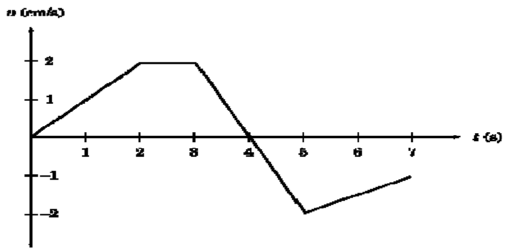
6.8 Application questions and problem solving

These were followed by application and problem solving where the experimental group could apply, transfer or generalize ideas relating to real world context. Some examples are given.

1. (a) Describe the following graphs.
   (b) Convert graphs 1, 4, 9, 10 & 11 into velocity-time and acceleration-time graphs.



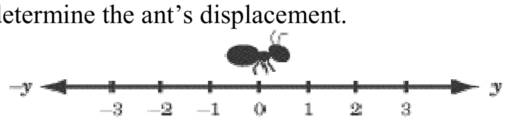
2. Calculate the gradients of the graph from t=0-2s, 2-3s, 3-5s and 5-7s.

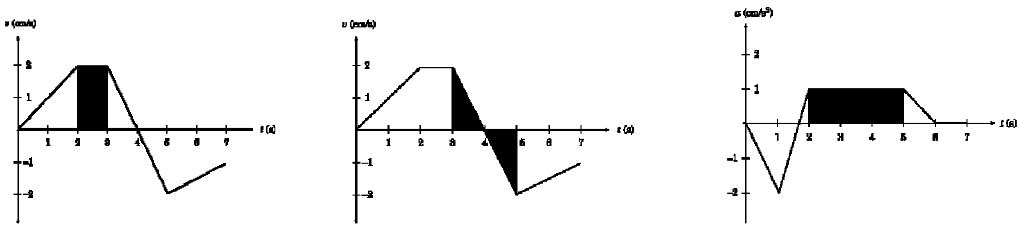


3. Give the meaning of the slope and area under the following graphs:

Graph	Slope	Area under the graph
position versus time	………………….	…………………………
velocity versus time	………………….	…………………………
acceleration versus time	………………….	………………………….

4. The following graphs were plotted by the movement of the ant shown in the diagram. From the shaded portions of the graphs determine the ant's displacement.





6.9 Control group

Students from the control group was lectured by their teacher on the plotting, conversion/ transformation and description on the shapes of kinematics graphs. Again students in control group (School B) was lectured on the meaning and calculation of slopes and areas under graphs. The teacher of the group also used the application questions in teaching.

6.10 Post-TUG-K

Students from the experimental and control groups were made to answer post- TUG-K questions on the last day (7^{th} day) of the lesson (Beichner, 1994). Their mean proportion post TUG-K scores were compiled.

The mean proportion pre- and-post TUG-K scores of the experimental and control groups were compared. Again, Hake's gain of the pre- and post-TUG-K were calculated and compared. Students used 30 minutes in answering the questions in each session, due to some quantitative problems involved in calculating slopes and areas under graphs.

TUG-K instrument could be grouped into four main concepts under graphs. These include:

- Area under graph (meaning and calculation)
- Slopes (meaning and calculation)
- Graph description
- Graph transformation

7. Results

Research question: Could MBL, simulations and graphs samples promote students interactive engagement teaching and learning, and enhance students' conceptual understanding of kinematics graphs?

To answer this research question, students from both experimental and control groups were made to answer pre and post TUG-K. The mean proportion pre and post TUG-K scores for each question was compiled for experimental and control groups and presented as Table 1, 2, 3 and 4.

Table 1: Mean proportion pre and post TUG-K scores for Experimental Group (School A- 45 students)

TUG- K Questions	No. of Students with correct Pre TUG-K Answers	Mean Proportion scores for Pre TUG-K	No. of Students with correct Post TUG-K Answers	Mean Proportion scores for Post TUG-K	Hake-Gain
1	20.0	0.44	35.0	0.78	0.60
2	11.0	0.24	28.0	0.62	0.50
3	15.0	0.33	39.0	0.87	0.80
4	16.0	0.36	42.0	0.93	0.90
5	17.0	0.38	26.0	0.58	0.32
6	14.0	0.31	23.0	0.51	0.29
7	18.0	0.40	30.0	0.67	0.44
8	12.0	0.27	38.0	0.84	0.79
9	14.0	0.31	33.0	0.73	0.61
10	16.0	0.36	36.0	0.80	0.69
11	14.0	0.31	37.0	0.82	0.74
12	19.0	0.42	39.0	0.87	0.77
13	09.0	0.20	23.0	0.51	0.39
14	11.0	0.24	38.0	0.84	0.79
15	10.0	0.22	36.0	0.80	0.74
16	17.0	0.37	43.0	0.96	0.93
17	23.0	0.56	41.0	0.91	0.82
18	18..0	0.40	39.0	0.87	0.78
19	16.0	0.35	33.0	0.73	0.59
20	24.0	0.53	44.0	0.98	0.95
21	15.0	0.33	39.0	0.87	0.80

From Table 1, the students' (experimental group-school A) mean proportion pre TUG-K scores were mostly below 0.5 with exception of questions 17 and 20. However, their mean proportion post TUG-K scores were mostly beyond 0.6, with exception of questions 5, 6 and 13 that their scores fell between 0.5 and 0.6. Also their Hake gain in each item was high with exception of item 6. The values fell within the medium-g courses and high-g courses.

Table 2: Mean proportion pre and post TUG-K scores for the Control Group (School B- 43 students)

TUG-K Questions	No. of Students with correct Pre TUG-K Answers	Mean Proportion scores for Pre TUG-K	No. of Students with correct Post TUG-K Answers	Mean Proportion scores for Post TUG-K	Hake-Gain
1	18.0	0.41	21.0	0.49	0.12
2	11.0	0.26	12.0	0.28	0.031
3	13.0	0.30	19.0	0.44	0.20
4	14.0	0.33	25.0	0.58	0.38
5	16.0	0.37	20.0	0.47	0.15
6	15.0	0.35	18.0	0.42	0.11
7	17.0	0.40	21.0	0.49	0.15
8	09.0	0.21	16.0	0.37	0.20
9	12.0	0.27	19.0	0.44	0.23
10	14.0	0.33	21.0	0.49	0.24
11	14.0	0.33	22.0	0.51	0.28
12	18.0	0.42	25.0	0.58	0.28
13	11.0	0.26	17.0	0.40	0.19
14	12.0	0.28	19.0	0.44	0.23
15	11.0	0.26	17.0	0.40	0.19
16	15.0	0.35	21.0	0.49	0.21
17	19.0	0.44	27.0	0.63	0.33
18	18..0	0.42	30.0	0.70	0.48
19	14.0	0.33	21.0	0.49	0.24
20	19.0	0.44	31.0	0.72	0.50
21	17.0	0.40	23.0	0.53	0.23

From Table 2, the students' (control group-school B) mean proportion pre TUG-K scores were under 0.50. In the post TUG-K most of the students had mean proportion scores of about 15 items under 0.50. The scores for the rest of the items were under 0.60 with the exception of about three of the items (17, 18 and 20), where the scores were 0.63, 0.70 and 0.72. Also, their Hake gain in each item was low. All the values fell within the low-g courses with exception of items 17, 18 and 20, which fell within the medium-courses.

Table 3: Conceptual understanding of kinematics graphs

Concept	Items in TUG-K under the concept	Group	Mean proportion scores of items on the concepts	
			Mean Pre TUG-K	***Mean Post TUG-K***
1. Area under graph (meaning and calculation)	1, 4, 10, 16, 18 & 20	Experimental	0.41	0.89
		Control	0.38	0.58
2. Slopes (meaning and calculation)	2, 5, 6, 7 & 17	Experimental	0.38	0.66
		Control	0.36	0.46
3. Graph description	3, 8, 9, 12, 19 & 21	Experimental	0.34	0.82
		Control	0.32	0.48
4. Graph transformation	11, 12, 13, 14, 15 & 19	Experimental	0.29	0.76
		Control	0.31	0.47

From Table 3, it is realized that the mean proportion pre TUG-K scores of both the experimental and control groups were quite similar, ranging from 0.29 to 0.41 for experimental group and from 0.31 to 0.38 for the control group. However, there was a significant difference between the experimental group and the control group in all the concepts. The mean proportion of the post TUG-K scores for the control group was from 0.46 to 0.58, whereas that in the experimental group was from 0.66 to 0.89.

Table 4: Mean proportion correct scores of Pre TUG-K, Post TUG-K, and Hake Gain

Academic Year Group	N	TUG-K		
		Pre (SD)	**Post (SD)**	**Hake Gain (SD)**
Experimental group	45	0.35(0.09)	0.79(0.14)	0.68(0.19)
Control group	43	0.34(0.07)	0.49(0.11)	0.24(0.11)

Students' mean proportion scores in pre TUG-K in both (experimental and control) groups were low. However, there was a considerable improvement in the mean proportion scores of the experimental group of post

TUG-K than their counterparts in the control group, though they also showed some improvement in their post TUG-K results. These were used to calculate the average normalized gain, $\langle g \rangle$ or the Hake gain. The Hake gain of the experimental group was higher than that in the control group. Thus, the overall Hake gain achieved by the experimental group was about 0.44 higher than the achievement of the control group.

8. Analysis of the results

From Tables 1 and 2, it is deduced that students from both experimental group and control group had almost equal mean proportion scores when they answered the pre TUG-K items. This goes to indicate the fact that students were at par as regards understanding of concepts in kinematics graphs. This is again confirmed in Table 3, which exhibited that students have similar conceptual understanding in area under graph (meaning and calculation), slopes (meaning and calculation), graph description and graph transformation.

After the use of the intervention such as the use of microcomputer based laboratory (MBL) tools, simulations and graph samples in the teaching of kinematics graphs on the experimental group and the use of traditional lecture method in the teaching of the kinematics graphs on the control group, there was a significant difference with regard to students mean proportion scores. It is realized that students from the experimental group improved more in their scores than the control group. Thus the use of the MBL tools, simulations and graph samples in the teaching and learning of concepts in kinematics graphs did have more positive impact on students from the experimental group than those who use the traditional lecture method. Again Table 3 did indicate that, and this goes to show that the use of microcomputer based laboratory (MBL) tools, simulations and graph samples in the teaching of kinematics graphs have significantly improved students understanding in the concepts of kinematics graphs; area under graph (meaning and calculation), slopes (meaning and calculation), graph description and graph transformation.

In search for teaching approaches (interactive and traditional lecture) that would yield a better conceptual understanding, Hake (1998) made a survey of 62 introductory physics courses with about 6500 students, where pre- and post-tests results were available for the conceptual reasoning tests of Halloun & Hestenes (FCI, MD and/or MBT). His measure of the average normalized gain, $\langle g \rangle$, to determine the average effectiveness of a course in promoting conceptual understanding was grouped into three:

- "High-g" courses as those with $(\langle g \rangle) \geq 0.7$;
- "Medium-g" courses as those with $0.7 > (\langle g \rangle) \geq 0.3$;
- "Low-g" courses as those with $(\langle g \rangle) < 0.3$.

Looking more closely into the instructional formats of those courses, Hake grouped them into two types of teaching; (i) Interactive Engagement methods and (ii) Traditional methods. He found out that teachers who made considerable use of interactive engagement methods in their teaching have their students achieving higher gains than those who were taught with the traditional lecture method. Hake classified interactive engagement methods as those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and /or instructors. Those reported by instructors to make little use of interactive engagement methods, relying primarily on passive-student lectures, recipe labs, and algorithmic-problem exams, were classified by him as traditional methods.

From Table 4, the researcher wanted to look at the two instructional formats that were used in the teaching of the experimental and the control group that would have the considerable use of interactive engagement teaching. Hence the average normalized gain, $\langle g \rangle$, which is the ratio of the difference between Post TUG-K and Pre TUG-K to the difference between 1 and Pre TUG-K;

$$\langle \mathrm{g} \rangle = [\frac{(\text{Post TUG - K} - \text{Pre TUG - K})}{(1 - \text{Pre TUG - K})}],$$

was used to calculate the gain of both the experimental and the control groups. Before the use of the instructional formats, both of the experimental group and the control group had almost the same average normalized gain, $\langle g \rangle$ of 0.35 and 0.34 respectively. This confirms the fact that the mode of approach that is usually used in teaching students in both schools might not be more of an interactive engagement approach. Perhaps, the traditional lecture approach was the predominant mode of approach used. However, after the introduction of the two different instructional formats, it was realized that the experimental group had more interactive engagement teaching and learning than that of the control group. Average normalized gain, $\langle g \rangle$ of 0.68 for the experimental group falls within the Hake's "Medium-g" courses, which is a typical range for average effectiveness of courses in promoting interactive engagement teaching which also enhances conceptual understanding (Hake, 1998).

However, average normalized gain, $\langle g \rangle$ of 0.24 for the control group falls within the Hake's "Low-g" courses, which also is a typical range of courses which do not promote the use of interactive engagement approach, such as the traditional lecture method of teaching. Hake developed his score for FCI but not for TUG-K, and along the same line the researcher extended his way of calculation for TUG-K gain scores. Finally, it was realized that the use of MBL, simulations and graph samples in teaching promote interactive engagement teaching than the use of traditional lecture method.

9.0 Conclusion

In conclusion, it has been noted that the use of microcomputer based laboratory (MBL) tools, simulations and graph samples in the teaching of kinematics graphs have significantly improved students understanding of the concepts of kinematics graphs; area under graph (meaning and calculation), slopes (meaning and calculation), graph description and graph transformation than the use of the traditional lecture approach in teaching.

Also, the use of microcomputer based laboratory (MBL) tools, simulations and graph samples in the teaching of kinematics graphs promoted more interactive engagement practices which enhanced more conceptual understanding among students. On the contrary, the use of the traditional lecture approach in the teaching of kinematics graphs did not promote interactive engagement, hence enough conceptual understanding in the kinematics graphs was not achieved in the control group. This result is in line with the results of the survey that Richard Hake did (Hake, 1998).

References

Beichner, R. J. (1994), "Testing student interpretation of kinematics graphs", *American Journal of Physics*, *6*2, 750-762.

Creswell, J.W. & Plano-Clark, V. (2007), "*Designing and conducting mixed methods research",* Sage Publications, Thousand Oaks, CA.

Crouch, C. H. & Mazur, E. (2001), "Peer Instruction: Ten years of experience and results", American *Journal of Physics,* 69*,* 970-977.

Dimitrov, D. M. & Rumrill Jr. P.D., (2003), *"Pretest-posttest designs and measurement",* Change 20(2), 159-165.

Ellis, G. W. & Turner, W. A. (2002), "Improving the conceptual understanding of kinematics through graphical analysis", Proceedings of the 2002 American society for engineering education annual conference & exposition.

Hake, R. R. (1998), "Interactive engagements versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics course, *American Journal of Phy*sics, 66, 64-74.

Halloun, I. A. & Hestenes, D. (1985), "The initial knowledge state of college physics students", *American Journal of Physics,* 53, 1056 –1065.

Kulik, C. C. & Kulik, J. A. (1991), "Effectiveness of computer-based instruction: An updated analysis", *Computers in Human Behavior,* 7(1), 75-94.

McDermott, C. L., Rosenquist, M. L. & van Zee, E. H. (1987), "Student difficulties in connecting graphs and physics: Examples from kinematics", *American Journal of Physics*, 55, 503-513.

McDermott, L. C. (1993), "Guest comment: How we teach and how students learn– a mismatch?", *American Journal of Physics,* 61*,* 295–298.

McDermott, L. C. (2001), "Oersted medal lecture 2001: physics education research-the key to student learning", *American Journal of Physics,* 69(11), 1127-1137.

Minter, E., & Michaud, M. (2003), "Using Graphics to Report Evaluation Results", Wisconsin: University of Wisconsin Cooperative Extension. [Online] Available: http://learningstore.uwex.edu/pdf/G3658-13.PDF 9 (February 5, 2015)

Mokros, R. J. & Tinker, R. F. (1997), "The impact of microcomputer-based labs on children's ability to interpret graphs", *Journal for Research Science Teaching*, 2(34), 369-383.

Moll, I. (2002), "Clarifying constructivism in a context of curriculum change", *Journal of Education,* 27, 5-32.

Murphy, L. D. (1999), "Graphing misinterpretations and microcomputer-based laboratory instruction, with emphasis on kinematics", Retrieved from: http://www.mste.uiuc.edu/Murphy/Papers/GraphinterpPaper.html.

Redding, C. W. (2014), "Effect of predicting motion on student understanding of kinematic graphs". *Master of Natural Sciences Thesis.*

Sokoloff, D. R. & Thornton, R. K. (1997), "Using interactive lecture demonstrations to create an active learning environment", *AIP Conference Proceedings,* 399, 1061.

Tebabal, A. & Kahssat, G. (2011), "The effects of student-centered approach in improving students' graphical interpretation skills and conceptual understanding of kinematical motion". Latin *American Journal of Physics,* 5(2).

Biodata of author

Victor Antwi is a senior lecturer at the University of Education, Winneba (UEW). He had his Ph.D in Physics Education in University of Utrecht, Utrecht, The Netherlands in 2013. He did his M. Phil Programme in Physics in University of Cape Coast (UCC), Cape Coast, Ghana in 2005. He has been teaching and supervising undergraduate Physics and post graduate physics students for about ten years in UEW. Currently, he is the Acting Head of Department of Early Childhood Education in UEW.